PATENT ABSTRACTS OF JAPAN

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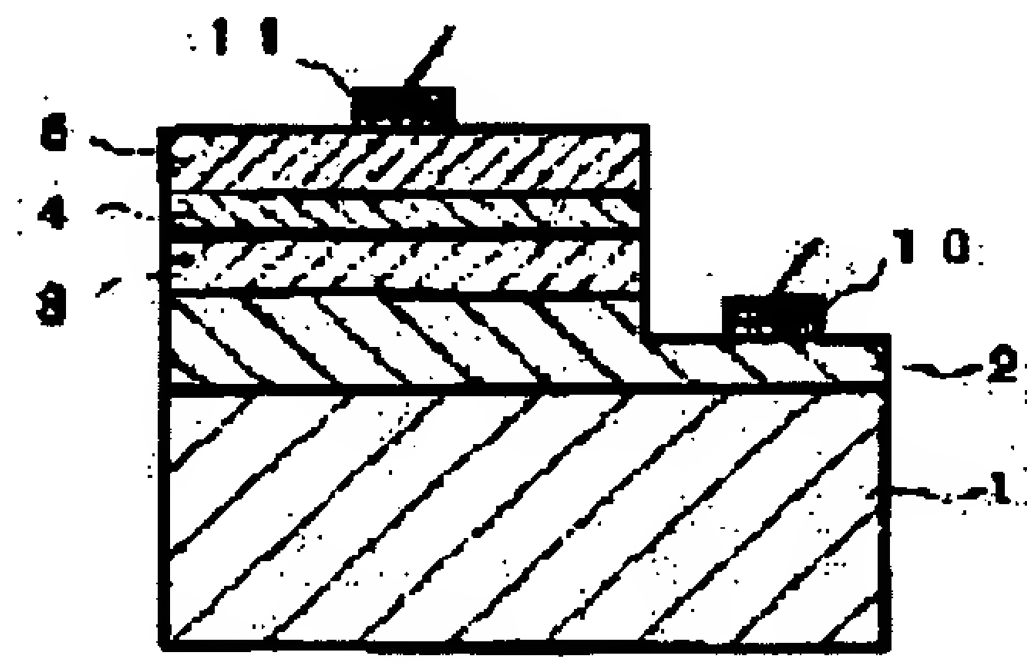
(54) GALLIUM NITRIDE COMPOUND SEMICONDUCTOR LIGHT EMITTING DIODE

(57)Abstract:
PURPOSE: To provide a gallium nitride compound semiconductor light emitting diode which is very stable in emission luminance and emission output power and more enhanced in characteristics, wherein the light emitting diode is of P-N junction-type double hetero-structure and possessed of an InGaN active layer and clad layers of N-type or P-type GaAlN.
CONSTITUTION: An N-type GaN contact layer 2, an N-type Ga1-XAXIN (0 ≤X≤1) first clad layer 3, an N-type or P-type Ga1-YInYN (0<Y<1) active layer 4, and a P-type Ga1-ZAIZN (0≤Z≤1) second clad layer 5 are successively laminated on a substrate 1, wherein the first clad layer 3 is set to 1×1017/cm3 to 1×1019/cm3 in electron carrier concentration to enhance a light emitting diode of this construction in emission luminance and emission output power.



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CLAIMS

[Claim(s)]

[Claim 1] The gallium-nitride system compound semiconductor light emitting device which is a gallium-nitride system compound semiconductor light emitting device characterized by providing the following, and is characterized by adjusting the electronic carrier concentration of the clad layer of the above first to the range of three to 1x1019/cm3 of 1x1017-/cm. The contact layer which consists of n type GaN at least on a substrate. The first clad layer which consists of n type Ga1-XAlXN (0<=X<=1). The barrier layer which consists of an n type or p type Ga1-YInYN (0< Y<1). Structure where the laminating of the second clad layer which consists of p type Ga1-ZAlZN (0<=Z<=1) was carried out to order.

[Claim 2] The gallium-nitride system compound semiconductor light emitting device according to claim 1 characterized by adjusting the electronic carrier concentration of the aforementioned contact layer to the range of three to 2x1019/cm3 of 5x1016-/cm.

[Claim 3] The aforementioned barrier layer is the claim 1 characterized by being n type Ga1-YInYN by which n type dopant, p type dopant or p type dopant, and n type dopant were doped, or a gallium-nitride system compound semiconductor light emitting device according to claim 2.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the gallium-nitride system compound semiconductor light emitting device used for ultraviolet, blue, green light emitting diode, laser diode, etc.
[0002]
[Description of the Prior Art] We proposed Japanese Patent Application No. No. 70873 [five to], Japanese Patent Application No. No. 70874 [five to], Japanese Patent Application No. No. 114541 [five to], Japanese Patent Application No. No. 114542 [five to], Japanese Patent Application No. No. 114543 [five to], Japanese Patent Application No. No. 114544 [five to], etc. about the gallium-nitride system compound semiconductor light emitting device of terrorism structure to the p-n junction type double which makes InGaN a barrier layer and uses n type and p type GaAlN as a clad layer. the gallium-nitride system compound semiconductor light emitting device from which the maximum brightness, such as conditions which change luminescence intensity of a light emitting device, such as conditions, such as a kind of dopant doped to InGaN which is a barrier layer, concentration, and carrier concentration, or a kind of dopant of p type clad layer, and concentration, to such technology, is obtained is indicated, and, specifically, we succeeded in realization of the blue light emitting device of 500 or more mcds which was not realized at all conventionally with the technology of these
[0003] However, according to the conditions of the gallium-nitride system compound semiconductor layer which still constitutes a light emitting device, dispersion will arise in the luminescence intensity of the obtained light emitting device, and a radiant power output, and the further improvement needs to be added as a light emitting device is manufactured using those technology.
[0004]
[Problem(s) to be Solved by the Invention] Therefore, while obtaining the luminescence brightness and radiant power output which were stabilized in the gallium-nitride system compound semiconductor light emitting device of terrorism structure to the p-n junction type double which this invention was accomplished in view of such a situation, and the place made into the purpose made InGaN the barrier layer, and used n type and p type GaAlN as the clad layer, it is in raising those properties further.
[0005]
[Means for Solving the Problem] The gallium-nitride system compound semiconductor light emitting device of this invention The contact layer which consists of n type GaN at least on a substrate, and the first clad layer which consists of n type Ga1-XAlXN (0<=X<=1), The barrier layer which consists of an n type or p type Ga1-YInYN (0< Y<1), It is the gallium-nitride system compound semiconductor light emitting device which has the structure where the laminating of the second clad layer which consists of p type Ga1-ZAlZN (0<=d<=1) was carried out to order. It is characterized by adjusting the electronic carrier concentration of the clad layer of the above first to the range of three to 1x1019/cm3 of 1x1017-/cm.
[0006] The cross section showing the structure of the gallium-nitride system compound semiconductor light emitting device of this invention is shown in drawing 1 . n type the n type Ga1-XAlXN layer an n type Ga1-aAlaN contact layer and whose 3 1 is the first clad layer as for a substrate and 2, and whose 4 are barrier layers or a p type Ga1-YInYN layer. the p type Ga1-ZAlZN layer whose 5 is the second clad layer, and 10 and 11 are electrodes.
[0007] Although sapphire, SiC, ZnO, etc. can be used for a substrate 1, sapphire is usually used. The light emitting device of the structure of drawing 1 shows the sapphire which is an insulating substrate. Moreover, if buffer layers, such as GaN and GaAlN, are formed between a substrate 1 and the contact layer 2, the crystallinity of the contact layer 2 which grows on a buffer layer will become good. especially in this invention, as indicated to JP,4-297023,A, by making a buffer layer the same as that of composition of the contact layer 2, the crystalline contact layer 2 which was very excellent is obtained, and the crystallinity of the gallium-nitride system compound semiconductor which grows on the contact layer 2 is markedly alike, and improves
[0008] Next, the contact layer 2 needs to be n type GaN. because, the contact layer 2 -- the duality of GaN -- as compared with mixed crystal, it considers as the 3 yuan mixed crystal which added aluminum -- if it is alike, and follows and grows up by thickness 0.3 micrometers or more -- under a crystal -- a crack -- entering -- being easy -- it is in the inclination for crystallinity to become bad If crystallinity becomes bad, on the contact layer 2, the crystallinity of the gallium-nitride system compound semiconductor which carries out a laminating will also become bad, and luminescence intensity and a radiant power output will decline. Moreover, if n type electrode 10 and an ohmic contact become is hard to be obtained, for example, aluminum is contained more than a half to Ga, it will become an electrode 10 and Schottky contact closely. Moreover, it is desirable three to 2x1019/cm3 of 5x1016-/cm and to adjust the electronic carrier concentration of the contact layer 2 to the range of three to 1x1019/cm3 of 1x1017-/cm still more preferably. When there is less the electronic carrier concentration than 1x1017-/cm3 and there is than 2x1019-/cm3, it is in the inclination for a radiant power output to decline. [more] It is better to adjust electronic carrier concentration as a desirable n type by doping and carrying out the crystal growth of the IV group element which are n type dopants, such as Si, germanium, Te, and Se, since it is difficult to adjust electronic carrier concentration only on growth conditions as it is a non dope, although there is a property in which a non dope also becomes n type as everyone knows in the case of a gallium-nitride system compound semiconductor.

[0009] next, the electronic carrier concentration of n type Ga1-XAlXN which is the first clad layer 3 — three to 1x1019/cm3 of 1x1017-/cm — it is necessary to adjust to the range of three to 8x1018/cm3 of 2x1017-/cm still more preferably If there is less the electronic carrier concentration than 1x1017-/cm3, since the resistivity of the first clad layer 3 will become high, consequently forward voltage will become high, luminous efficiency falls. Since ther is still l ss electronic carrier concentration, it is poured into the part and a barrier layer 4 and electronic carrier reduction is carried out, luminous efficiency falls. Moreover, if [than 1x1019/cm3] more, the half-value width of the X-ray rocking curve of the first clad layer 3 will become 10 minutes from about 5 minutes, and crystallinity will fall clearly. Therefore, on th first bad crystalline clad layer 3, since the crystalline improvement in a barrier layer is not found even if it carries out the laminating of the barrier layer 4, the luminous efficiency of a light emitting device falls. It is indispensable requirements to adjust the rate of this fall to the aforementioned range, since the first clad layer 2 is larger than change of the electronic carrier concentration of the contact layer 2. Although it cannot be overemphasized that n type dopant can be doped and adjusted like the contact layer 2 for adjusting electronic carrier concentration, in this first clad layer 2, having used Si most preferably tends to adjust electronic carrier concentration.
[0010] n type is sufficient as the Ga1-YInYN layer which is a barrier layer, and p type is sufficient as it. To consider as n type in the state of a non dope, or a Ga1-YInYN layer It can consider as n type by doping and carrying out the crystal growth of the aforementioned n type dopant. Moreover, it can consider as p type by carrying out annealing above 400 degrees C after the Ga1-YInYN layer growth which is made to carry out a crystal growth or contains p type dopant so that II group element which are p type dopants, such as Zn, Mg, and calcium, may be doped to consider as p type and p type property may be shown. As shown in Japanese Patent Application No. No. 70874 [five to], most preferably p type dopant, Or [whether the Ga1-YInYN layer dopes p type dopant and n type dopant, and it was made to become n type is made into a barrier layer, and] Or a radiant power output and luminescence intensity increase by making into a barrier layer the Ga1-YInYN layer which doped n type dopant and adjusted electronic carrier concentration to the range of three to 5x1021/cm3 of 1x1017-/cm.
[0011] The p type Ga1-ZAlZN layer which is the second clad layer can do the Ga1-ZAlZN layer which carried out annealing above 400 degrees C and which was used as desirable p type after the Ga1-ZAlZN layer growth containing the Ga1-ZAlZN layer which carried out the crystal growth so that p type dopant might be doped as mentioned above and p type property might be shown, or p type dopant with the second clad layer. A radiant power output and luminescence intensity can be increased by using the p type Ga1-ZAlZN layer which doped Mg as a p type dopant by the density range of three to 1x1021/cm3 of 1x1018-/cm like [it is desirable and] a Japanese Patent Application No. [No. 114544 / five to] publication.
[0012]
[Function] Drawing 2 is drawing showing the relation of the electronic carrier concentration of the first clad layer, and the luminescence intensity of a light emitting device, and this is set to the light-emitting-device light emitting device of the structure of drawing 1 . An Si dope n type GaN layer and the first clad layer 3 for the contact layer 2 An Si dope n type GaAlN layer, A Zn and Si dope n type InGaN layer and the second clad layer 5 are made into a blue light emitting device with a main luminescence wavelength of 460nm for a barrier layer 4 as a Mg dope GaAlN layer, and the relative value of the luminescence intensity at the time of changing only the electronic carrier concentration of the first clad layer is shown. Each point (-) of drawing 2 shows the electronic carrier concentration 5x1016, 1x1017, 2x1017, 3x1017, 1x1018, 5x1018, 8x1018, 1x1019, and 2x1019-/cm3 sequentially from the lower one. In this invention, the range which falls to 10% is made into the limited value of the electronic carrier concentration of the first clad layer to the highest luminescence intensity, and let the range of the electronic carrier concentration which has 50 more% or more of luminescence intensity be a still more desirable range so that you may understand, even if it sees this drawing.
[0013] Moreover, the relative value of luminescence intensity when drawing 3 is similarly drawing showing the relation of a light emitting device with the electronic carrier concentration of the contact layer 2 and changes only the electronic carrier concentration of the contact layer 2 in the above-mentioned light emitting device also with this same and the light emitting device of the same structure is shown. In addition, in this drawing, electronic carrier concentration of the first clad layer 3 was set to 1x1018-/cm3. Each point (**) of drawing 3 shows the electronic carrier concentration 3x1016, 5x1016, 1x1017, 5x1017, 1x1018, 5x1018, 1x1019, 2x1019, and 5x1019-/cm3 sequentially from the lower one. Therefore, in the light emitting device of this invention, the range which falls to 10% is made into the range with the desirable electronic carrier concentration of a contact layer to the highest luminescence intensity, and it considers as the range which has 50% or more of luminescence intensity as a still more desirable range.
[0014]
[Example] By the [example 1] MOCVD method, on silicon on sapphire with a thickness of 300 micrometers An Si dope GaN layer as 200A and a contact layer for the buffer layer which consists of GaN 4 micrometers, Si dope Ga0.9aluminum0.1N layer as first clad layer 0.1 micrometers, The gallium-nitride system compound semiconductor wafer which carried out the laminating of the 0.1 micrometers for the p mold Ga0.9aluminum0.1N layer which doped Mg for the n mold In0.1Ga0.9N layer which doped Zn and Si as a barrier layer as 0.1 micrometers and second clad layer to order was created. In addition, the electronic carrier concentration of the contact layer of this wafer was 1x1018-/cm3, and 1x1018-/cm3 and the electronic carrier concentration of a barrier layer of the electronic carrier concentration of the first clad layer were 1x1019-/cm3.
[0015] Next, it etches, after forming a predetermined mask in the front face of the clad layer of the above second, and the contact layer for forming n electrode is exposed. After forming an electrode in p clad layer and exposed n contact layer according to a conventional method, annealing was performed above 400 degrees C and the p mold Ga0.9aluminum0.1N layer which is the second clad layer was further formed into low resistance.
[0016] When the wafer obtained as mentioned above was cut out in the shape of a chip and light was made to emit as a blue light emitting device, in 20mA of forward voltage, Vf is 4.3V and the luminescence brightness in the main luminescence wavelength of 460nm showed 1400mcd(s), 1600micro of radiant power outputs W, and the greatest ever luminescence brightness and a radiant power output.
[0017] When 0.3-micrometer laminating of the Mg dope p type GaN layer was further carried out as second contact layer and also it considered as the blue light emitting device similarly on the second clad layer p mold Ga0.9aluminum0.1N layer of

the [example 2] example 1, in 20mA, forward voltage fell 3.2V and became luminescence brightness 1600mcd and 2000micro of radiant power outputs W. In addition, the electrode by the side of p cannot be overemphasized by having formed in the second contact layer.

[0018] In case the contact layer of the [example 3] example 1 was formed, when it set electronic carrier concentration to 5x1016-/cm3 and also considered as the light emitting device similarly, they were radiant-power-output 300microW and luminescence brightness 200mcd.

[0019] In case the first clad layer of the [example 4] example 1 was formed, when it set electronic carrier concentration to 1x1017-/cm3 and also considered as the light emitting device similarly, they were output 200microW and luminescence brightness 150mcd.

[0020]

[Effect of the Invention] As explained above, the luminescence intensity of a light emitting device and a radiant power output improve by leaps and bounds by adjusting the electronic carrier concentration of first n type clad layer which constitutes the light emitting device from a light emitting device of this invention. Moreover, also in the electronic carrier concentration of n type contact layer which should prepare the electrode of n layers, if the value is adjusted, the radiant power output of a light emitting device and luminescence intensity can be raised like the first clad layer. And the stable luminescence brightness and the light emitting device which has a radiant power output can be offered, and the utility value on industry has a very large thing.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The type section view showing the structure of the light emitting device of one example of this invention.

[Drawing 2] Drawing showing the relation between the electronic carrier concentration of the first clad layer, and the luminescence intensity of a light emitting device.

[Drawing 3] Drawing showing the relation between the electronic carrier concentration of a contact layer, and the luminescence intensity of a light emitting device.

[Description of Notations]

1 ... Substrate
2 ... n type Ga1-aAlaN contact layer
3 ... n type Ga1-XAlXN clad layer
4 ... n or p type Ga1-YInYN barrier layer
5 ... p type Ga1-ZAlZN clad layer

[Translation done.]

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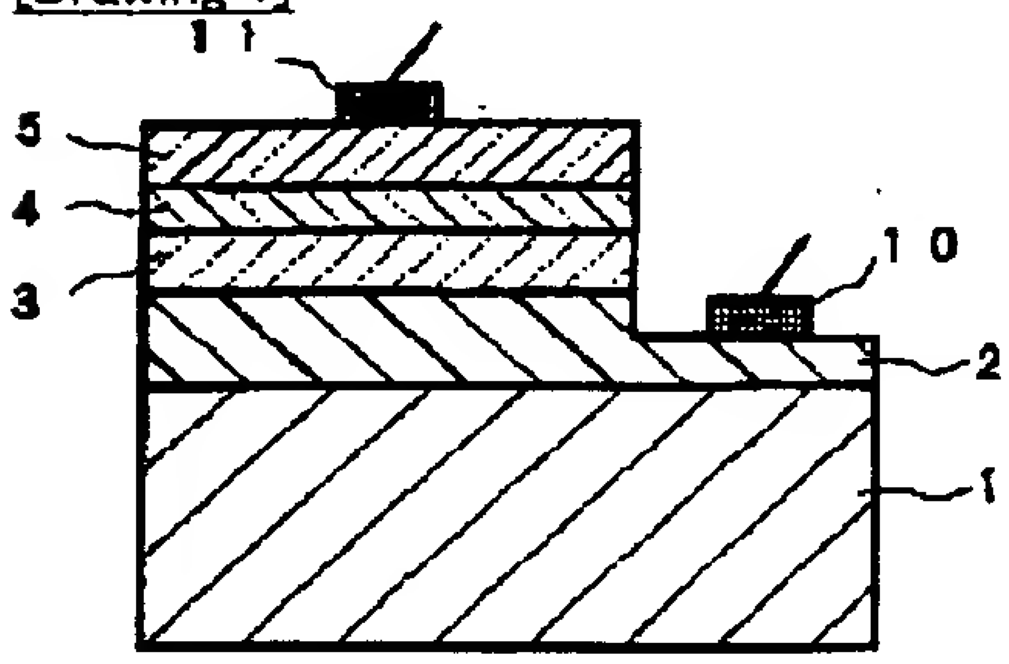
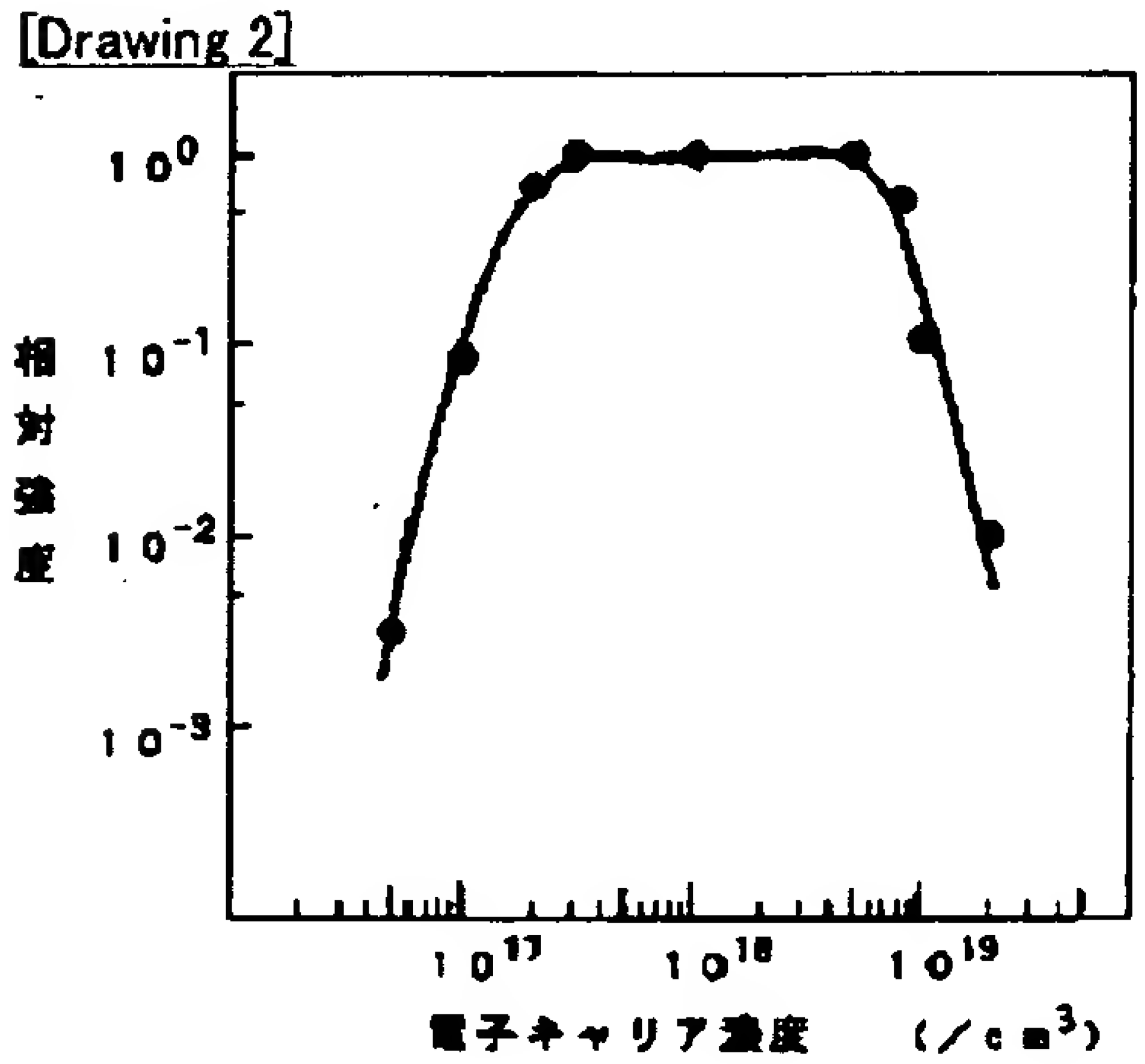
DRAWINGS

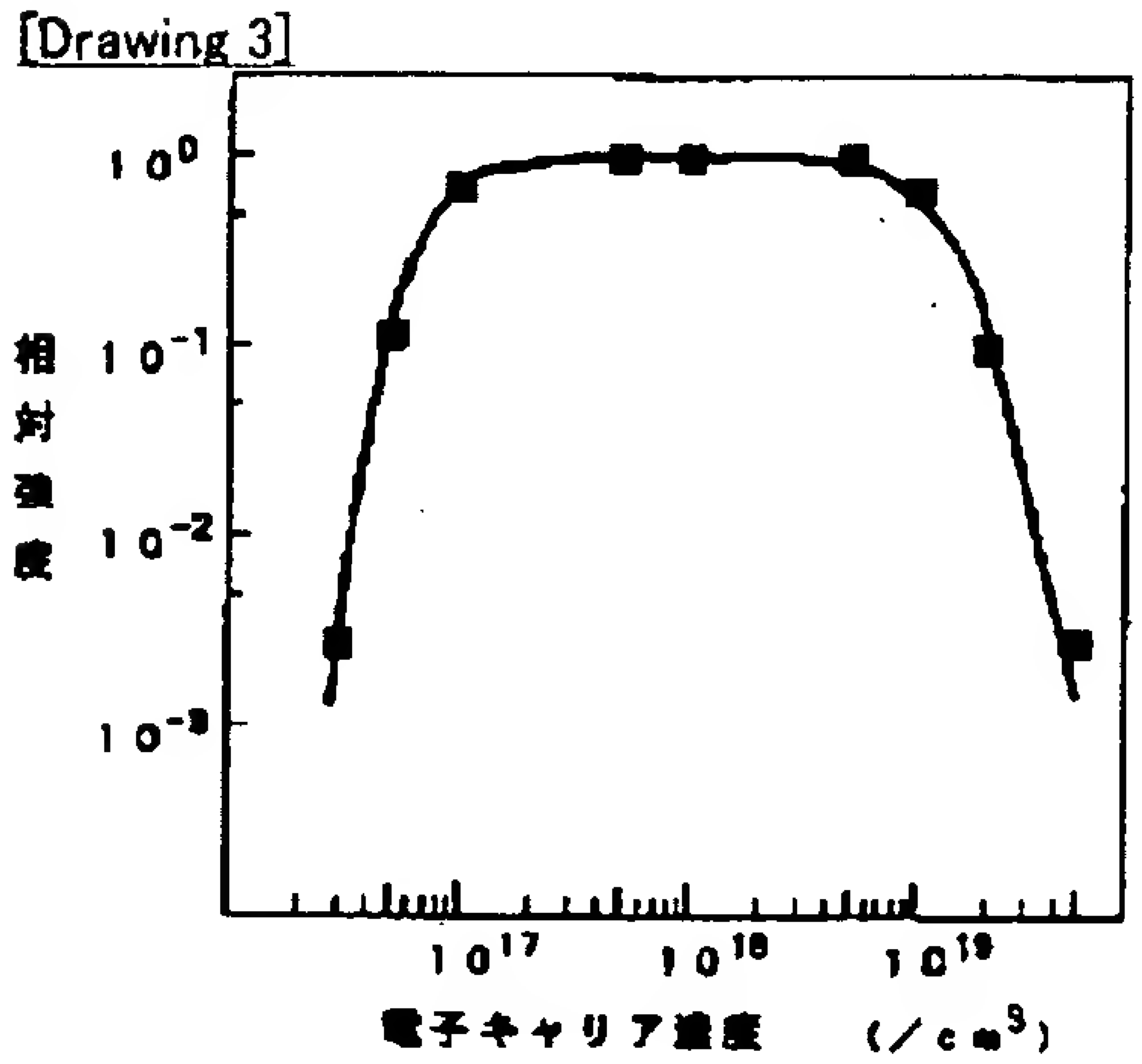
[Drawing 1]



[Drawing 2]



[Drawing 3]



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CORRECTION or AMENDMENT

[Official Gazette Type] Printing of the amendment by the convention of 2 of Article 17 of patent law.
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[FI]

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[Procedure revision]
[Filing Date] May 13, Heisei 8.
[Procedure amendment 1]
[Document to be Amended] Specification.
[Item(s) to be Amended] Claim.
[Method of Amendment] Change.
[Proposed Amendment]
[Claim(s)]
[Claim 1] The gallium-nitride system compound semiconductor light emitting device which is a gallium-nitride system compound semiconductor light emitting device of terrorism structure in the double characterized by providing the following, and is characterized by adjusting the electronic carrier concentration of the clad layer of the above first to the range of three to 1x1019/cm3 of 1x1017-/cm. The first clad layer to which a band gap consists of a large n type gallium-nitride system compound semiconductor rather than a barrier layer at least on a substrate. The barrier layer which consists of an n type containing an indium, or a p type gallium-nitride system compound semiconductor. The second clad layer which a band gap becomes from large p type nitride semiconductor rather than a barrier layer.
[Claim 2] The gallium-nitride system compound semiconductor light emitting device according to claim 1 characterized by having the contact layer which consists of n type GaN between the aforementioned substrate and the clad layer of the above 1st.
[Claim 3] The gallium-nitride system compound semiconductor light emitting device according to claim 2 characterized by adjusting the electronic carrier concentration of the aforementioned contact layer to the range of three to 2x1019/cm3 of 5x1016-/cm.
[Claim 4] The aforementioned barrier layer is a gallium-nitride system compound semiconductor light emitting device given in any 1 term of the claim 1 characterized by doping n type dopant, p type dopant or p type dopant, and n type dopant, and specifying the conductivity type, or the claims 3.
[Procedure amendment 2]
[Document to be Amended] Specification.
[Item(s) to be Amended] 0004.
[Method of Amendment] Change.
[Proposed Amendment]
[0004]
[Problem(s) to be Solved by the Invention] Therefore, while obtaining the luminescence brightness and radiant power output which were stabilized in the gallium-nitride system compound semiconductor light emitting device of terrorism structure to the p-n junction type double to which this invention was accomplished in view of such a situation, the place made into the purpose made InGaN the barrier layer, and the band gap used the large gallium-nitride system compound semiconductor as the clad layer rather than barrier layers, such as n type and p type GaN, and GaAlN, it is in raising those properties further.

[Procedure amendment 3]
[Document to be Amended] Specification.
[Item(s) to be Amended] 0005.

[Method of Amendment] Change.
[Pr posed Amendment]
[0005]
[Means for Solving the Problem] The gallium-nitride system compound semiconductor light emitting device of this invention The first clad layer to which a band gap consists of a large n type gallium-nitride system compound semiconductor rather than a barrier layer at least on a substrate. The barrier layer which consists of an n type containing an indium, or a p type gallium-nitride system compound semiconductor. It is the gallium-nitride system compound semic nductor light emitting device of terrorism structure in the double which has the second clad layer which consists of a barrier layer from p type nitride semiconductor with a large band gap. It is characterized by adjusting the electronic carrier concentration of the clad layer of the above first to the range of three to 1x1019/cm3 of 1x1017-/cm. In the light emitting device of this invention, as for the first clad layer, it is desirable that it is n type Ga1-XAlXN (0<=X<=1). as for a barrier layer, it is desirable that it is Ga1-YInYN (0< Y<1), and, as for the second clad layer, it is desirable that it is p type Ga1-ZAlZN (0<=Z<=1). It is desirable to have the contact layer which consists of n type GaN between the aforementioned substrate and the clad layer of the above first further again, and, as for the electronic carrier concentration of the n type GaN contact layer, it is most desirable to be adjusted to the range of three to 2x1019/cm3 of 5x1016-/cm.
[Procedure amendment 4]
[Document to be Amended] Specification.
[Item(s) to be Amended] 0006.
[Method of Amendment] Change.
[Proposed Amendment]
[0006] The cross section showing one structure of the gallium-nitride system compound semiconductor light emitting device of this invention is shown in drawing 1. n type the n type Ga1-XAlXN layer an n type GaN contact layer and whose 3 1 is the first clad layer as for a substrate and 2, and whose 4 are barrier layers or a p type Ga1-YInYN layer, the p type Ga1-ZAlZN layer whose 5 is the second clad layer, and 10 and 11 are electrodes.

[Translation done.]

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Ｈ０１Ｓ　3/18				

審査請求　未請求　請求項の数3　ＯＬ　（全 5 頁）

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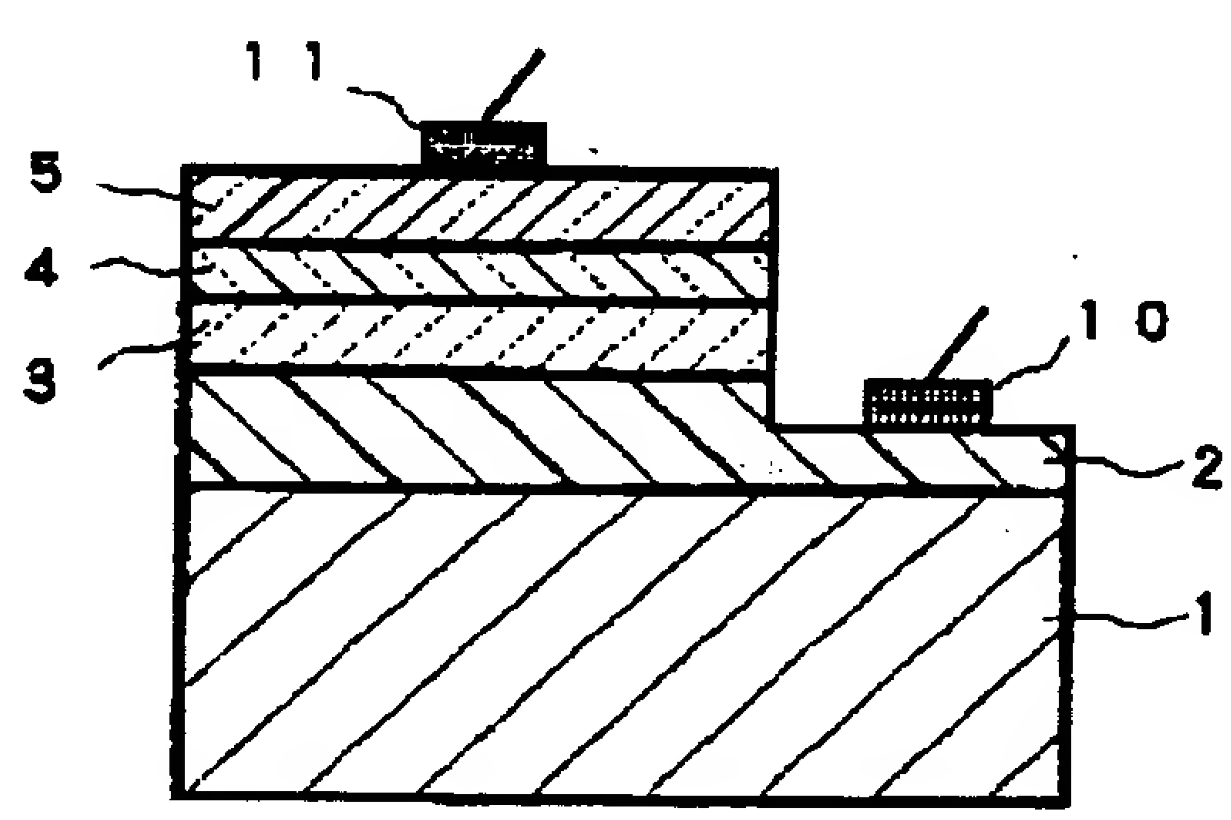
(54)【発明の名称】　窒化ガリウム系化合物半導体発光素子

(57)【要約】　（修正有）

【目的】　ＩｎＧａＮを活性層とし、ｎ型およびｐ型のＧａＡｌＮをクラッド層としたｐ－ｎ接合型ダブルヘテロ構造の窒化ガリウム系化合物半導体発光素子において、安定した発光輝度、発光出力を得ると共に、それらの特性をさらに高める。

【構成】　基板１上に少なくともｎ型ＧａＮよりなるコンタクト層２と、ｎ型$Ga_{1-X}Al_XN$（$0 \leqq X \leqq 1$）よりなる第一のクラッド層３と、ｎ型あるいはｐ型の$Ga_{1-Y}In_YN$（$0 < Y < 1$）よりなる活性層４と、ｐ型$Ga_{1-Z}Al_ZN$（$0 \leqq Z \leqq 1$）よりなる第二のクラッド層５とが順に積層されており、第一のクラッド層３の電子キャリア濃度が$1 \times 10^{17}/cm^3 \sim 1 \times 10^{19}/cm^3$の範囲にすることにより、発光輝度、発光出力を向上させる。



【特許請求の範囲】

【請求項1】　基板上に少なくともn型GaNよりなるコンタクト層と、n型$Ga_{1-X}Al_XN$（0≦X≦1）よりなる第一のクラッド層と、n型あるいはp型の$Ga_{1-Y}In_YN$（0＜Y＜1）よりなる活性層と、p型$Ga_{1-Z}Al_ZN$（0≦Z≦1）よりなる第二のクラッド層とが順に積層された構造を有する窒化ガリウム系化合物半導体発光素子であり、前記第一のクラッド層の電子キャリア濃度が$1×10^{17}/cm^3$～$1×10^{19}/cm^3$の範囲に調整されていることを特徴とする窒化ガリウム系化合物半導体発光素子。

【請求項2】　前記コンタクト層の電子キャリア濃度が$5×10^{16}/cm^3$～$2×10^{19}/cm^3$の範囲に調整されていることを特徴とする請求項1に記載の窒化ガリウム系化合物半導体発光素子。

【請求項3】　前記活性層はn型ドーパント、もしくはp型ドーパント、またはp型ドーパントとn型ドーパントとがドープされたn型$Ga_{1-Y}In_YN$であることを特徴とする請求項1、または請求項2に記載の窒化ガリウム系化合物半導体発光素子。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は紫外、青色、緑色発光ダイオード、レーザーダイオード等に使用される窒化ガリウム系化合物半導体発光素子に関する。

【0002】

【従来の技術】InGaNを活性層とし、n型およびp型のGaAlNをクラッド層とするp－n接合型ダブルヘテロ構造の窒化ガリウム系化合物半導体発光素子に関し、我々は特願平5－70873号、特願平5－70874号、特願平5－114541号、特願平5－114542号、特願平5－114543号、特願平5－114544号等を提案した。これらの技術には、活性層であるInGaNにドープするドーパントの種類、濃度、キャリア濃度等の条件、あるいはp型クラッド層のドーパントの種類、濃度等、発光素子の発光強度を変化させる条件等、最大輝度が得られる窒化ガリウム系化合物半導体発光素子が開示されており、具体的には、これらの技術により、我々は従来全く実現されていなかった500mcd以上の青色発光素子の実現に成功した。

【0003】しかし、それらの技術を用い発光素子を製作するに従い、未だ発光素子を構成する窒化ガリウム系化合物半導体層の条件により、得られた発光素子の発光強度、発光出力にばらつきが生じ、さらなる改良を加える必要が生じてきた。

【0004】

【発明が解決しようとする課題】従って本発明はこのような事情を鑑み成されたものであり、その目的とするところは、InGaNを活性層とし、n型およびp型のGaAlNをクラッド層としたp　n接合型ダブルヘテロ構造の窒化ガリウム系化合物半導体発光素子において、安定した発光輝度、発光出力を得ると共に、それらの特性をさらに高めることにある。

【0005】

【課題を解決するための手段】本発明の窒化ガリウム系化合物半導体発光素子は、基板上に少なくともn型GaNよりなるコンタクト層と、n型$Ga_{1-X}Al_XN$（0≦X≦1）よりなる第一のクラッド層と、n型あるいはp型の$Ga_{1-Y}In_YN$（0＜Y＜1）よりなる活性層と、p型$Ga_{1-Z}Al_ZN$（0≦d≦1）よりなる第二のクラッド層とが順に積層された構造を有する窒化ガリウム系化合物半導体発光素子であり、前記第一のクラッド層の電子キャリア濃度が$1×10^{17}/cm^3$～$1×10^{19}/cm^3$の範囲に調整されていることを特徴とする。

【0006】本発明の窒化ガリウム系化合物半導体発光素子の構造を示す断面図を図1に示す。1は基板、2はn型$Ga_{1-X}Al_XN$コンタクト層、3は第一のクラッド層であるn型$Ga_{1-X}Al_XN$層、4は活性層であるn型またはp型の$Ga_{1-Y}In_YN$層、5は第二のクラッド層であるp型$Ga_{1-Z}Al_ZN$層、10、および11は電極である。

【0007】基板1にはサファイア、SiC、ZnO等を使用し得るが、通常はサファイアを用いる。図1の構造の発光素子では絶縁性基板であるサファイアを示している。また、基板1とコンタクト層2との間にGaN、GaAlN等のバッファ層を形成すると、バッファ層の上に成長するコンタクト層2の結晶性がよくなる。特に本発明においては、特開平4－297023号に開示したように、バッファ層をコンタクト層2の組成と同一にすることにより、非常に優れた結晶性のコンタクト層2が得られ、コンタクト層2の上に成長する窒化ガリウム系化合物半導体の結晶性が格段に向上する。

【0008】次にコンタクト層2はn型GaNであることが必要である。なぜなら、コンタクト層2はGaNの二元混晶に比して、Alを加えた三元混晶とするに従い、0．3μm以上の膜厚で成長すると結晶中にクラックが入りやすくなり、結晶性が悪くなる傾向にある。結晶性が悪くなるとそのコンタクト層2の上に積層する窒化ガリウム系化合物半導体の結晶性も悪くなり、発光強度、発光出力が低下する。またn型電極10とオーミックコンタクトが得られにくくなり、例えばAlがGaに対し半分以上含まれると、電極10とショットキー接触に近くなる。またコンタクト層2の電子キャリア濃度は$5×10^{16}/cm^3$～$2×10^{19}/cm^3$、さらに好ましくは$1×10^{17}/cm^3$～$1×10^{19}/cm^3$の範囲に調整することが好ましい。その電子キャリア濃度が$1×10^{17}/cm^3$より少なく、また$2×10^{19}/cm^3$よりも多いと発光出力が低下する傾向にある。窒化ガリウム系化合物半導体の場合には、周知のようにノンドープでもn型になる性質があるが、ノンドープであると成長条件のみで電子キ

【特許請求の範囲】

【請求項1】　基板上に少なくともn型GaNよりなるコンタクト層と、n型$Ga_{1-X}Al_XN$ ($0 \leqq X \leqq 1$) よりなる第一のクラッド層と、n型あるいはp型の$Ga_{1-Y}In_YN$ ($0 < Y < 1$) よりなる活性層と、p型$Ga_{1-Z}Al_ZN$ ($0 \leqq Z \leqq 1$) よりなる第二のクラッド層とが順に積層された構造を有する窒化ガリウム系化合物半導体発光素子であり、前記第一のクラッド層の電子キャリア濃度が1×10^{17}/cm³～1×10^{19}/cm³の範囲に調整されていることを特徴とする窒化ガリウム系化合物半導体発光素子。

【請求項2】　前記コンタクト層の電子キャリア濃度が5×10^{16}/cm³～2×10^{19}/cm³の範囲に調整されていることを特徴とする請求項1に記載の窒化ガリウム系化合物半導体発光素子。

【請求項3】　前記活性層はn型ドーパント、もしくはp型ドーパント、またはp型ドーパントとn型ドーパントとがドープされたn型$Ga_{1-Y}In_YN$であることを特徴とする請求項1、または請求項2に記載の窒化ガリウム系化合物半導体発光素子。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は紫外、青色、緑色発光ダイオード、レーザーダイオード等に使用される窒化ガリウム系化合物半導体発光素子に関する。

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マスクを形成した後エッチングを行い、n電極を形成するためのコンタクト層を露出させる。pクラッド層と露出したnコンタクト層とに常法に従い電極を形成した後、400℃以上でアニーリングを行い第二のクラッド層であるp型$Ga_{0.9}Al_{0.1}N$層を更に低抵抗化した。

【0016】以上のようにして得たウェーハをチップ状に裁断し、青色発光素子として発光させたところ、順方向電圧20mAにおいて、Vfは4．3Vであり、主発光波長460nmにおける発光輝度は1400mcd、発光出力1600μWと過去最大の発光輝度、発光出力を示した。

【0017】［実施例2］実施例1の第二のクラッド層p型$Ga_{0.9}Al_{0.1}N$層の上に、さらに第二のコンタクト層としてMgドープp型GaN層を0．3μm積層する他は同様にして青色発光素子としたところ、20mAにおいて順方向電圧が3．2Vに低下し、発光輝度1600mcd、発光出力2000μWとなった。なお、p側の電極は第二のコンタクト層に形成してあることは言うまでもない。

【0018】［実施例3］実施例1のコンタクト層を形成する際、電子キャリア濃度を5×10^{16}／cm³とする他は同様にして発光素子としたところ、発光出力300μW、発光輝度200mcdであった。

【0019】［実施例4］実施例1の第一のクラッド層を形成する際、電子キャリア濃度を1×10^{17}／cm³とする他は同様にして発光素子としたところ、出力200μW、発光輝度150mcdであった。

【0020】

【発明の効果】以上説明したように、本発明の発光素子ではその発光素子を構成する第一のn型クラッド層の電子キャリア濃度を調整することにより、発光素子の発光強度、発光出力が飛躍的に向上する。またn層の電極を設けるべきn型コンタクト層の電子キャリア濃度においても、その値を調節すれば、第一のクラッド層と同様に発光素子の発光出力、発光強度を向上させることができる。しかも、安定した発光輝度、発光出力を有する発光素子を提供することができ、産業上の利用価値は非常に大きいものがある。

【図面の簡単な説明】

【図1】　本発明の一実施例の発光素子の構造を示す模式断面図。

【図2】　第一のクラッド層の電子キャリア濃度と発光素子の発光強度との関係を示す図。

【図3】　コンタクト層の電子キャリア濃度と発光素子の発光強度との関係を示す図。

【符号の説明】

1・・・基板

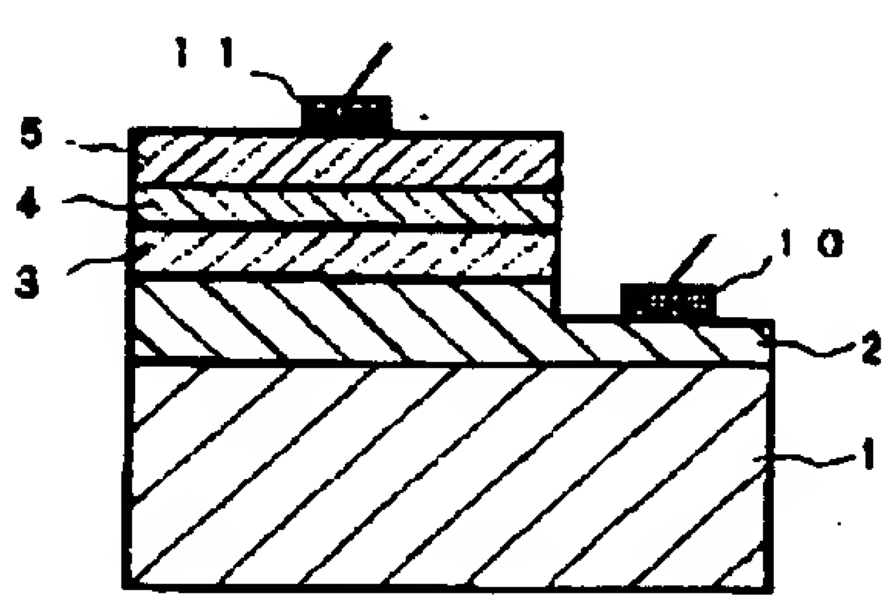
2・・・n型$Ga_{1-a}Al_aN$コンタクト層

3・・・n型$Ga_{1-X}Al_XN$クラッド層

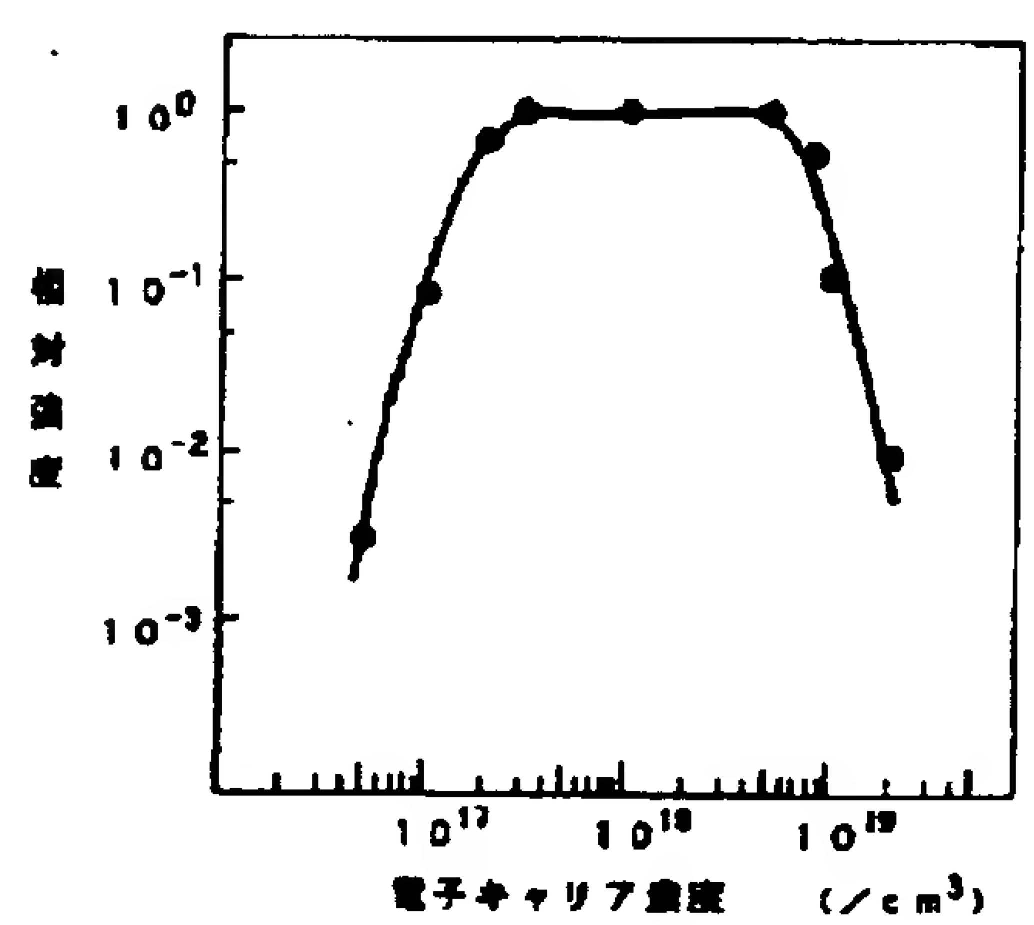
4・・・nまたはp型$Ga_{1-Y}In_YN$活性層

5・・・p型$Ga_{1-Z}Al_ZN$クラッド層

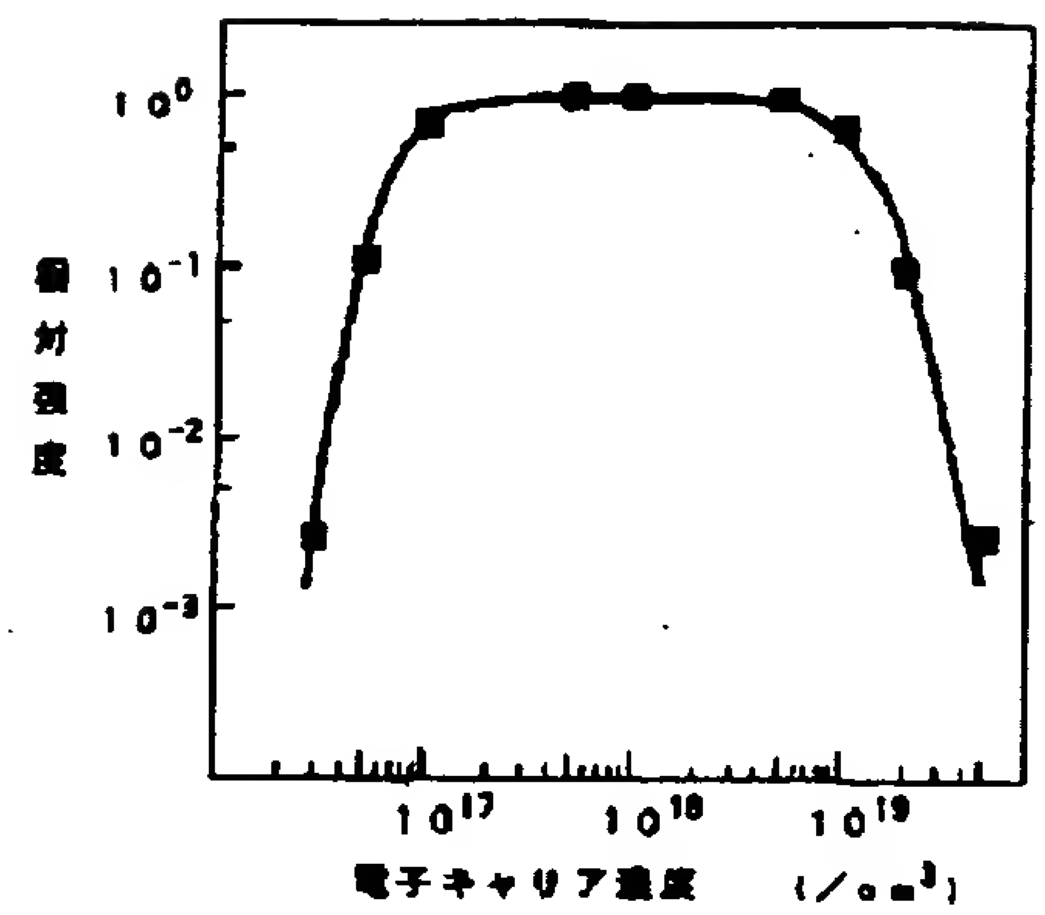
【図1】



【図2】



【図3】



【手続補正書】

【提出日】平成5年12月17日

【手続補正1】

【補正対象書類名】明細書

【補正対象項目名】0006

【補正方法】変更

【補正内容】

【0006】　本発明の窒化ガリウム系化合物半導体発光素子の構造を示す断面図を図1に示す。1は基板、2はn型GaNコンタクト層、3は第一のクラッド層であるn型$Ga_{1-X}Al_XN$層、4は活性層であるn型またはp型の$Ga_{1-Y}In_YN$層、5は第二のクラッド層であるp型$Ga_{1-X}Al_XN$層、10、および11は電極である。

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